Soil Evaluator Course
Chapter One

Introduction

On-site treatment and disposal of sewage is the only method of wastewater renovation in over 25 % of the housing units in Massachusetts. Recent changes in Title 5, the state's environmental code, call for a site evaluation by soil evaluators. These individuals assess the estimated maximum groundwater elevation, the soil textural class of the various soil layers below the proposed leaching facility, and the presence of performance restricting soil layers. This document provides information on the general performance of on-site sewage disposal systems including the fate of nutrients, suspended and dissolved solids, and bacteria and viruses. The second portion of the document is concerned with the soil factors affecting treatment performance and efficiency.

About one-third of all housing units in the United States are not connected to a central sewer collection system and rely on on-site treatment and disposal of sewage. Over 500,000 housing units in Massachusetts rely on this method to dispose of domestic wastewater. More than 70 million gallons of renovated water are returned daily to the groundwater by on-site sewage disposal (OSD) systems in Massachusetts. This replenishment of our groundwater aquifers may be negatively impacted by incomplete treatment of the wastewater. On-site sewage disposal is thought to be a significant contributor to groundwater pollution, endangering the quality of the groundwater resource, which serves as the primary source for drinking water in most Massachusetts communities. Even when properly sited, designed, constructed and operated septic systems is a significant source of nitrogen. This nutrient, particularly in the nitrate form, causes hemoglobinemia (blue baby syndrome) in infants and, when occurring in high quantities, may affect the general quality of the environment. This effect is especially significant in coastal wetlands where excess nitrogen in the ecosystem may cause excessive growth of algae and higher plants.

Disposal of domestic sewage has environmental and public health concerns which need to be addressed in the siting, design, construction and operation of on-site sewage disposal systems. Over the years states have updated their regulations of OSD systems to reflect increasing knowledge of these systems. In Massachusetts, Title 5 sets forth a number of requirements to improve the siting, design and installation of OSD systems to ensure safe and non-polluted surface and groundwaters. One of the big changes is an improved site assessment procedure to be carried out by a soil evaluator. This individual must evaluate the potential of a proposed site for on-site sewage including determination of the textural class (relative proportion of sand, silt and clay) of each layer and the estimated maximum groundwater elevation. In addition, potential restrictions of that site should be noted including the presence of flow restricting layers, presence of 4 feet of naturally occurring pervious soil and other aspects that may affect system performance. This change to a soil-based system follows a national trend that was initiated over 15 years ago. Most New England states adopted soil-based OSD regulations years ago.

This document provides the background on the performance of OSD systems, in particular as affected by soils. The first portion describes the general principles of on-site treatment, including the contribution of the various components of the conventional septic system. This includes the fate of solids, dissolved organics, nutrients, viruses and, bacteria, and the role of edaphic factors on treatment and disposal efficiency.

SYSTEM COMPONENTS

The conventional septic system consists of the following three components: the waste generating unit, septic tank, and the leaching facility. The waste generated by various users has different characteristics depending on the use of the building, the number of persons served, the standard of living, and many other factors. Title 5 directs the system designer to assess potential characteristics of the proposed wastewater and incorporate these in the design. Certain uses such as dry-cleaners, garages, manufacturing plants, etc. often are incompatible with conventional on-site sewage disposal. Typical figures cited in this document assume that the system is used for domestic purposes. Information pertaining to other systems may be obtained from operating systems elsewhere, EPA design manuals, and Title 5.

Wastewater Generating Unit

The quantity and quality of sewage varies from house to house. Some dwellings are occupied by a few retired people, while others contain large extended families. In addition to the actual number of residents, the quality of the wastewater is much affected by the practices of family members. Some individuals use large quantities of water, however, they may dispose of only limited quantities of solids resulting in fairly diluted wastewater. On the other hand, some persons and families produce large amounts of solids that have the potential to quickly overwhelm the system. Houses equipped with garbage grinders tend to produce large amounts of solids that may cause system failure, particularly when the use of such an appliance was not anticipated in the design of the original system.

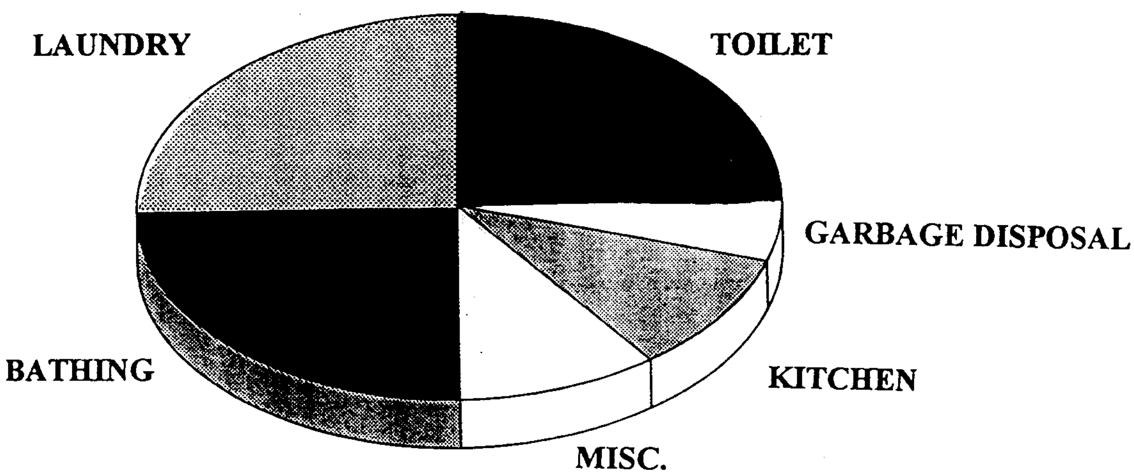

Fig. 1. Typical daily use of domestic wastewater per person.

The daily volume of an "average" person is depicted in Fig. 1. This "typical" person produces 45-60 gallons of wastewater per day, with an average of about 50 gallons per day. While the combined volume of toilets and garbage disposals only constitutes about 30% of the daily flow, the strength of these components in terms of solid material (suspended solids) far exceeds that value. Laundry and bathing contributes a large portion of the total daily wastewater volume, however, these components only contribute a small portion of the solids and nutrients. Use of low-volume toilets, low-flow showerheads, and high efficiency washers and dishwashers reduce the overall volume of the flow. The net effect is a more concentrated wastewater leading to a greater treatment efficiency, particularly when combined with the larger 1,500 gallon septic tanks now required by the new Title 5.

When discussing septic systems a distinction is made between actual and design flow. As stated previously, actual flow varies from person to person and therefore cannot be used in the actual design. The problem is compounded by the fact that the design has to anticipate the potential number of occupants in a dwelling, rather than the number of individuals that actually will live there. Title 5 therefore employs a design flow that is much larger than the actual flow. Such an approach is standard procedure in any engineering design to prevent premature failure. The resulting safety factor of 2 (110 gallons design flow/55 gallons actual flow) should be sufficient to ensure the longevity of the system provided that it is properly maintained, i.e. pumped regularly, without use of any caustic materials, and no garbage disposal unless anticipated in the system design.

Septic Tank

The septic tank is a large vessel, generally made out of concrete, which serves as a waste separation basin for the suspended solids in the wastewater. The septic tank may be compared to a large lake into which a turbulent mountain stream flows. The latter flows rapidly on account of the relatively steep gradient and the large volume of water relative to the dimensions of the stream channel. Due to its velocity, the stream is able of carrying sands in suspension, while at very high flow velocities even large rocks may be moved. Once the turbulent stream reaches the lake, the gradient is sharply reduced, accordingly the stream velocity slows down to virtually zero, and the sediments are deposited in a delta. The sewer pipe from the house is like the mountain stream, carrying large particles due to the steep gradient of the sewer and the relatively large volume of water. As soon as the waste stream reaches the septic tank the flow slows down. The presence of a T at the end of the outflow pipe dissipates the energy in the wastewater stream and the particles heavier than water slowly sink to the bottom of the tank and accumulate as sludge. The lighter particles, including grease, oils and waxes float to the top and accumulate in the scum layer. Presence of the T's and oftentimes baffles both at the in- and outflow points prevent the scum layer from clogging the pipes or leaving the tank in the effluent.

A typical cross-section of a septic tank is provided in Fig. 2.

The sludge accumulates over time and eventually needs to be removed by pumping. The frequency of pumping varies depending on the customs of the occupants. An elderly couple living in a large house produces only a small amount of solids. A large family in a dwelling with few bedrooms, a garbage disposal, and using lots of fatty foods will produce a large amount of solids that may overwhelm even a properly designed modern system. The latter family probably needs to pump every year, whereas the elderly couple can get by with much less frequent pumpings. A good rule of thumb is to pump the tank every three years and adjust the rate according to the amount of sludge and scum present. Older septic tanks that are smaller than the presently required 1,500 gallons should be pumped more frequently.

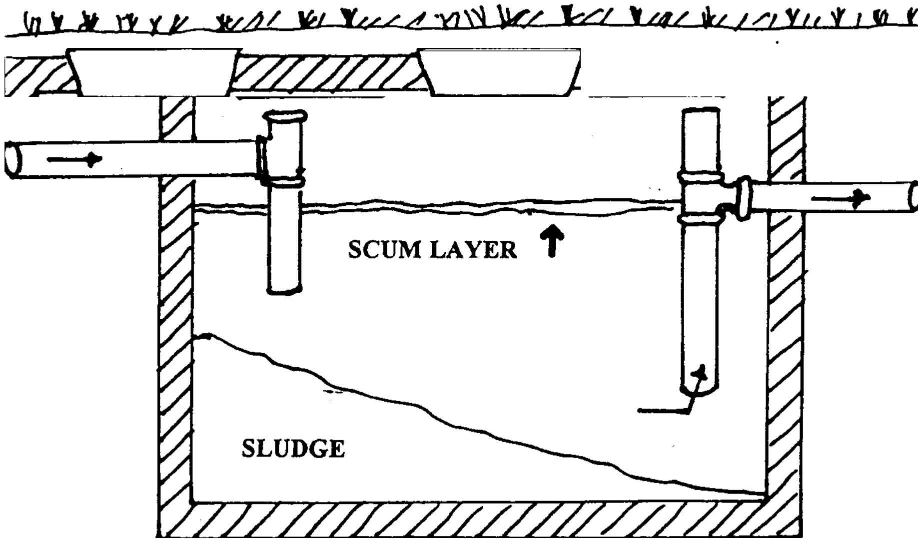

Fig. 2. Schematic cross section of a septic tank. Dimensions are not to scale.

Separation of solids is the principal function of septic tanks in a conventional septic system and very little actual treatment takes place. The tank is sized to provide a wastewater residency time of 2 to 3 days even when the tank is partially filled with sludge. This period should provide for settlement of all but the smallest particles which generally are too small and remain in suspension for a long period of time. Increasing the size of the tank beyond a reasonable level does not provide additional settling, but forces the tank to become anaerobic. Although anaerobic septic tank conditions are sometimes desirable in alternative technologies, this is not acceptable in conventional systems. The resulting anaerobic digestion produces gases that refloat the sludge, a phenomenon called sludge bulking. Rather than a reduction in suspended solids (SS), we end up with an increase in the volume of suspended solids which may eventually overload the leaching facility.

Table 1 shows the degree of suspended solids (SS) and nutrient removal in the septic tank. Suspended solids are reduced to less than 40% of the original volume. The amount of

Table I. Concentrations of selected parameters in household sewage and septic tank effluent.

	Total Suspended Solids mg/L	BOD mg/L	Nitrogen mg/L	Phosphorous mg/L
Sewage	400	350	80	35
Septic Tank Effluent	140	150	50	20

oxygen required to oxidize all organic matter, expressed as BOD, is reduced to a value slightly above 40%. The difference between the reduction in SS and BOD is due to dissolved organics. The reduction in nitrogen and phosphorous is not as pronounced as the SS values because these nutrients are mostly dissolved rather than associated with solid particles. As can be imagined, the septic tank contains large amounts of microorganisms some of which are pathogenic. Use of regular household cleaners will not significantly affect the microbial population, and additions of enzymatic or microbial cultures to enhance the microbial population generally are not needed. Application of septic tank additives generally is prohibited under Title 5 unless DEP has determined that the product does not cause harm to the system or to the environment. Contact your regional DEP office for a listing of approved products. Click [here] for a list of products allowed for use by DEP. [http://www.state.ma.us/dep/brp/wwm/consumer.htm]

Leaching Facility

Following the initial separation of solids in the septic tank, the effluent flows either to a distribution box (D-box) or to a pumping chamber. In the following discussion we will assume that the flow proceeds from the distribution box to the actual leaching facility by gravity flow. The case of pumped systems will be revisited in a later section. Septic tank effluent still contains pollutants, including microbes, and therefore needs to be discharged in a properly located sub-surface leaching facility ensuring complete removal of suspended solids; nutrients, and pathogens before the fluid reaches the groundwater.

Several different types of leaching facilities are permitted under Title 5. Choice of a particular system depends on local site and environmental conditions, area available for on-site sewage disposal, and the designer's preference. As far as soil parameters are concerned it does not make much difference which system is used. Trench systems will be used in the following examples because they are the preferred Title 5 system. Once a certain amount of sewage is generated in the house, an equal amount of effluent leaves the septic tank and enters the leaching facility. In most gravity-fed systems, only the first 5 to 10 feet of distribution pipe within the leaching facility contribute to the distribution of effluent. In a new system, the effluent flows only in a small portion of the leaching facility leading to a concentrated,

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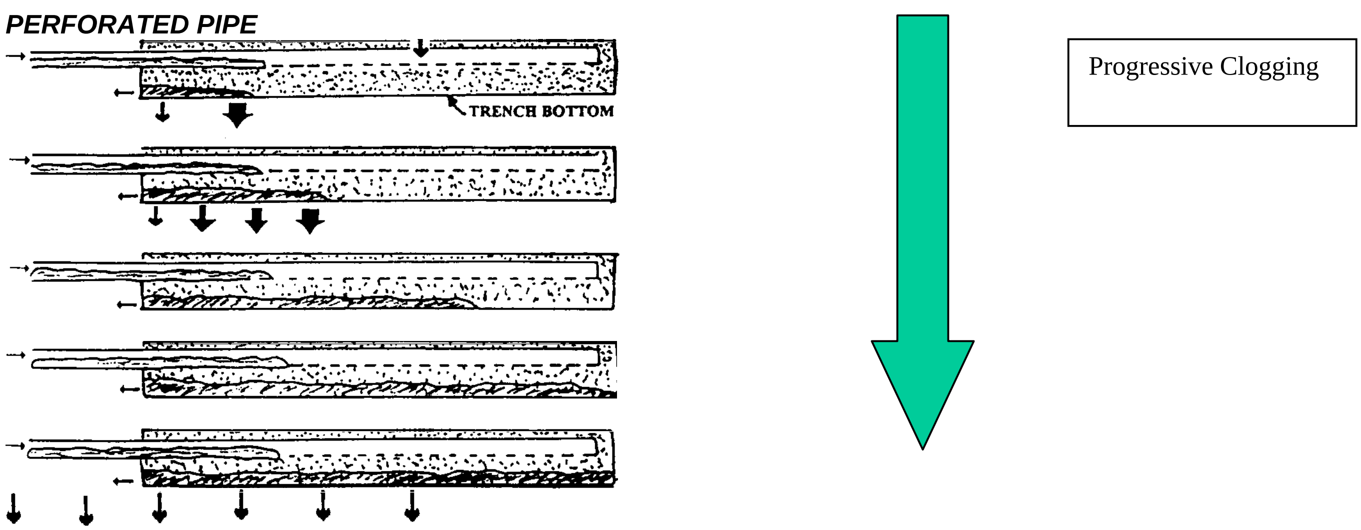

Fig. 3. Progressive development of the clogging layer or biomat. Full maturity generally is reached after about 6 months.

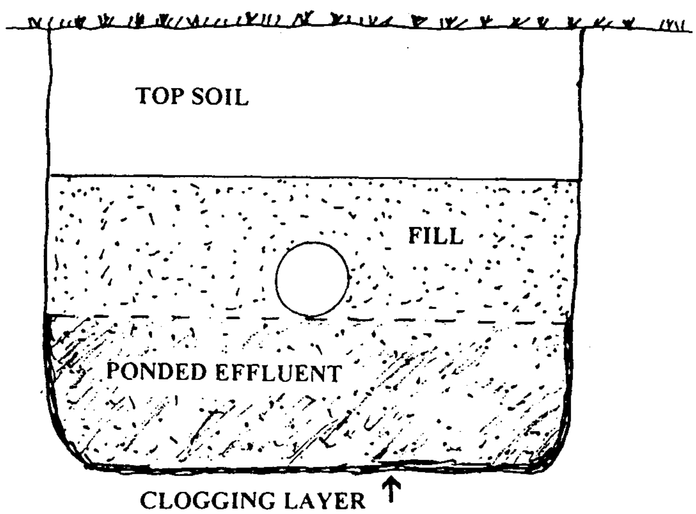

Fig. 4. Clogging layer developed in a trench.

saturated and rapid downward flow. Rapid flow does not allow for proper treatment and most septic systems will provide little treatment during the initial months after installation. After a short time, the suspended solids in the septic tank effluent increasingly become entangled in the labyrinth of soil pores at the gravel/soil interface. Once this process starts it accelerates as more and more particles become trapped. After several months, most of the pores have become clogged in a process called progressive clogging, depicted in Fig. 3. The organics in the clogging layer become a food substrate for the plethora of microorganisms present in septic tank effluent. These organisms strongly enhance anaerobic digestion of the accumulated organic materials and in turn produce slimes and inorganic compounds such as iron sulfide (FeS). These compounds, make the developing clogging layer or biomat even less pervious and after about a half year the clogging layer is complete and in equilibrium with the septic tank effluent. A typical biomat in a trench cross section is shown in Fig. 4.

Development of the clogging layer originally was thought to interfere with the disposal of sewage. In the past various remedies, including sulfuric acid and certain oxidants, were used to remove the developing clogging layer. Later research indicated that the presence of the clogging layer strongly enhanced treatment efficiency. The presence of unsaturated soil below the leaching facility is essential for effective effluent treatment. Unsaturated conditions prevent rapid movement of effluent through large pores and force the effluent to flow through the medium and small pores, or the soil matrix. Either way, the flow rate is substantially reduced under aerobic conditions, thereby increasing the residence time within the soil environment. For example, the flow rate is lowered from a few minutes per inch in a saturated sand to 20 to 30 days under unsaturated conditions. The unsaturated flow promotes entrapment of pollutants and pathogens, while the oxidizing conditions enhance the die-off and oxidation of pathogens and organics, respectively. Leaching facilities should be placed close to the soil surface to enhance the gaseous exchange between the soil and the atmosphere. The leaching area should remain uncovered; in situations were the facility is installed under an impervious surface such as a parking lot, the soil below the leaching facility should be properly aera-ted.

The amount of septic tank effluent that can be transmitted through the clogging layer per unit area stabilizes after the layer has reached equilibrium with the incoming effluent. This rate is called the long-term acceptance rate (LTAR); although the degree of clogging directly affects the transmittal rate of effluent, the rate is also dependent on soil type. In section 310 CMR.15.242 of Title 5, LTAR values are presented as a function of soil textural class. Figure 5 depicts the progressive clogging taking place as a function of loading rate. Excessive loading of the system results in heavy clogging and corresponding very low LTAR values. Eventually this leads to system failure. This effect is more pronounced in sandy soils since the difference between saturated conductivity and unsaturated conductivity with heavy clogging is more pronounced than that in loamy soils loaded at the same rates as is indicated by the size of the arrows in Fig. 5. If the engineer or sanitarian had based the system design on the saturated conductivity, the value of which is somewhat comparable to the percolation rate, only a few square feet of soil should be sufficient to dispose of all the effluent. In reality we know that leaching facilities need to be made much larger to accommodate the effects of the clogging layer. Over the years, most leaching facilities have been designed increasingly larger as our recognition of the effects of the biomat became more evident. The LTAR values in Title 5 are based on long-term experience in Massachusetts and elsewhere, and should ensure that modern systems will last a lifetime.

The extent of clogging depends on the quality and quantity of wastewater applied, the degree of pretreatment in the septic tank, the dimensions of the leaching facility, and the soil texture. In sandy soils, the exchange of gases between the soil and atmosphere is generally fairly rapid. Presence of oxygen in the soil just below the clogging layer enhances oxidation and therefore limits the degree of clogging. In very coarse-grained soils (coarse sands and coarser) the clogging layer may actually never fully develop, particularly in very large systems where only a minimum amount of wastewater is applied or in systems serving seasonal dwellings. The use of dosing systems (see later section) or sequential systems is recommended under these conditions. In finer grained soils this gaseous exchange is not as rapid resulting in less oxidizing conditions just below the clogging layer and leading to a slightly higher degree of clogging.

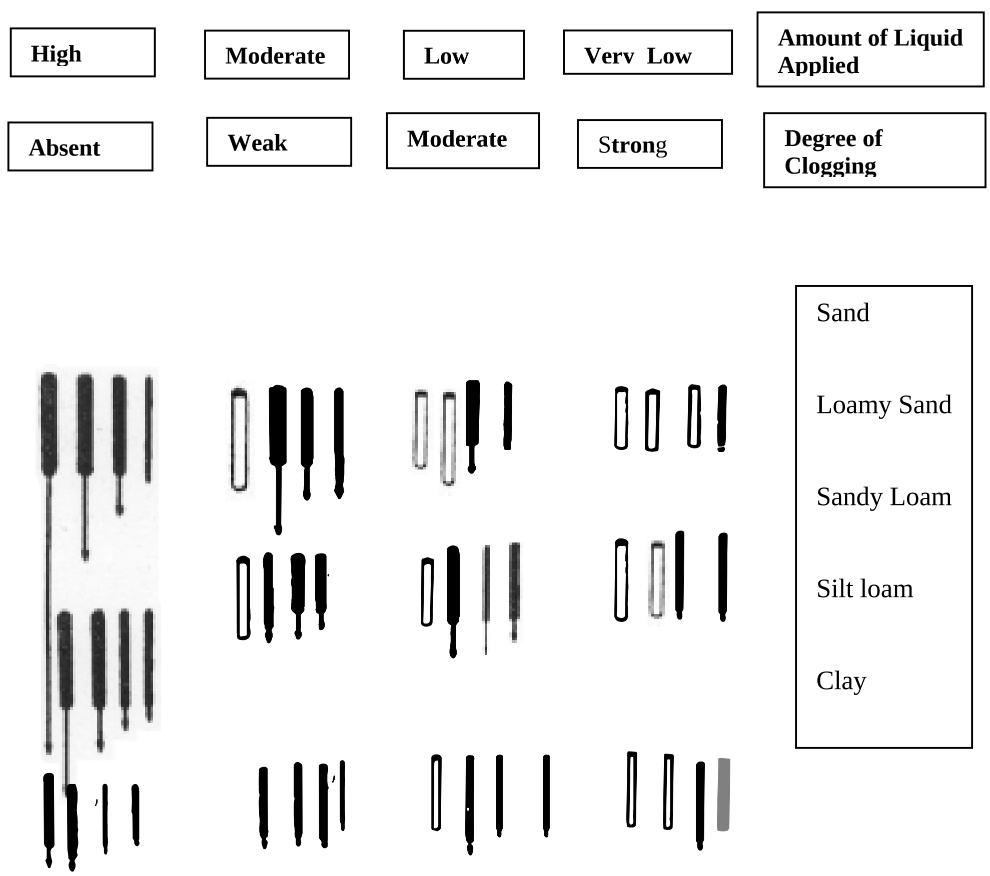

Fig. 5. Effect of clogging and loading rate on the amount of fluid that can be transmitted through the clogging layer as a function of textural class. Dark colored pores are filled with water.

EFFICACY OF SEPTIC SYSTEMS

Septic Tank

The primary function of the septic tank is separation of solids. This is accomplished by settling of the heavy particles in the sludge layer and through accumulation of the waxes, greases and other light components in the scum layer. These processes are essential to the proper operation of the OSD system and little additional treatment takes place. Because the sludge and scum tend to accumulate over time, the system needs to be pumped regularly to ensure that the septic tank retains its effective volume.

Leaching Facility

Actual treatment, in the form of biological or non-biological processes resulting in the degradation and complete or partial removal of wastewater constituents, generally takes place in the soil environment. Table 1 indicates that septic tank effluent contains significant quantities of suspended organic solids that need to be converted to environmentally more benign compounds. In addition, the effluent contains nutrients including nitrogen and phosphorus, and literally billions of microorganisms, a portion of which may be pathogenic. In recent years, regulatory agencies have become more diligent in pursuing the potential environmental and public health risks that septic systems may pose. Proper siting, design and installation ensure the development of a clogging layer and/or the presence of unsaturated and oxidizing conditions below the leaching facility. It is the task of the soil evaluator to ensure that the OSD system is properly sited in a location that guaranties almost perpetual operation of the system in a manner that enhances environmental quality and eradicates pathogens. The following sections will discuss the environmental and public health concerns associated with septic systems in greater detail.

Suspended Solids

As explained previously, any system that has just been placed in operation has an under-developed clogging layer whereby the largest soil pores still remain open and permit some transport of suspended solids to the natural soil underlying the leaching facility. Once the clogging layer in the leaching facility has matured, the bulk of the suspended solids is retained in the clogging layer. These organic compounds are degraded by microbial action into carbon dioxide and water. In unsaturated soil, large pores that potentially can transport contaminants rather rapidly are empty and filled with air. The septic tank effluent is forced to travel a tortuous path through the soil matrix, mainly through relatively small pores and films of water covering the soil particles. The wastewater percolates through the unsaturated soils not as rapid as it would in saturated soils, and travel times increase significantly. This results in greater residence times of wastewater in the soil environment, from a few hours to weeks, enhancing treatment efficiency. Some dissolved organics may travel with the septic tank effluent through the clogging layer into the soil below the leaching facility and are oxidized in the unsaturated soil below the leaching facility. By the time the wastewater reaches the groundwater, essentially all organics have been removed by oxidation. Parallel to the reduction in organics from the percolating wastewater, BOD and COD will diminish to background levels.

Nutrients

Domestic wastewater contains a host of nutrients that can be considered contaminants, including sodium, potassium, nitrogen and phosphorus. The latter two elements are of most concern from an environmental point of view. Each of the elements may be limiting biological processes. Additions of the nutrient that is in shortest supply will result in strong growth of plants, algae, and microorganisms until the element is used up or another nutrient becomes limiting. Phosphorus (P) tends to be limiting in most freshwater systems, whereas nitrogen (N) tends to be limiting in coastal regions. Release of nitrogen to the coastal environment will result in increased plant and algae growth. Upon die-off of the excess plant material, oxygen is used up rapidly and the entire aquatic system may turn anaerobic. This results in fish kill and excess accumulation of the plant and animal remains. Phosphorus generally regulates aquatic plant production in freshwater environments, although occasionally nitrogen may be limiting during the late summer months, even in freshwater systems.

Phosphorus in septic effluent tends to be in the dissolved orthophosphate form which moves readily through the clogging layer. In the unsaturated zone below the leaching facility, the phosphorus is removed from the wastewater by chemical precipitation. In acid soils the phosphate will form insoluble compounds with aluminum and iron, in calcareous soils it precipitates with calcium or magnesium. Most Massachusetts soils are fairly acid with a pH value of around 5 and iron is the principal co-precipitant with the orthophosphate. Some soils in Berkshire and northern Worcester counties are more acidic with a pH around 3.8, and there both iron and aluminum precipitate P. West of the Housatonic River soils tend to be calcareous and the phosphate will precipitate with calcium. Research indicates that the 4 feet of unsaturated soil (5 feet in sandy soils) provides sufficient amounts of iron and aluminum to sustain phosphorus removal for a prolonged time period. Experience with existing systems tends to reinforce the idea that phosphorus does not seem to be a problem in properly engineered systems. Problems have been reported in areas where systems (often cesspools) have been installed in seasonally wet soils.

Nitrogen occurs in the septic tank in the soluble ammonium (NH^{+}) form. Once the effluent leaches through the clogging layer into the unsaturated and aerated subsoil, the ammonium is quickly converted into nitrate ($NO3$). This latter compound, being negatively charged, is repelled by the negatively charged soil particles and is not retained in the soil. Every conventional system, even when operating under optimal design conditions will leach nitrogen. For a family of four living on a one-acre lot, taking into account the diluting effect of precipitation derived groundwater recharge, the final concentration of the effluent is about 6 mg/L when it reaches the groundwater. This is well below the federal drinking water standard of 10 mg/L NO -N. In lots not connected to a central sewer collection system and with a private on-site well, the minimum required area is 40,000 square feet to limit nitrate contamination of the groundwater. In nitrogen sensitive areas, in other words those areas where nitrogen is the growth-limiting nutrient, removal of nitrogen is required before the wastewater can be discharged. Innovative technologies are presently being evaluated for their potential for nitrogen removal. Recirculating sand filters, the RUCK system, peat filters as well as some other technologies show promise for enhanced nitrogen removal.

Pathogens

Sewage by its very nature contains many microorganisms. The majority of these is benign and will not cause any problems for humans. However, pathogenic microorganisms, including bacteria and viruses, do occasionally occur depending on the health status of the dwelling's inhabitants. Research has indicated that as far as microorganisms are concerned the degree of purification in a leaching facility depends strongly on the loading rate, that is the amount of effluent applied per square foot. Figure 6 clearly indicates that a 3-fold increase in loading rate (from 3 mm to 1 cm) results in a million times greater breakthrough of selected bacteria after a period of 2 to 3 months. Once the original 3-mm loading rate was reestablished, the bacteria count fell back to less than 10 per 100 ml.

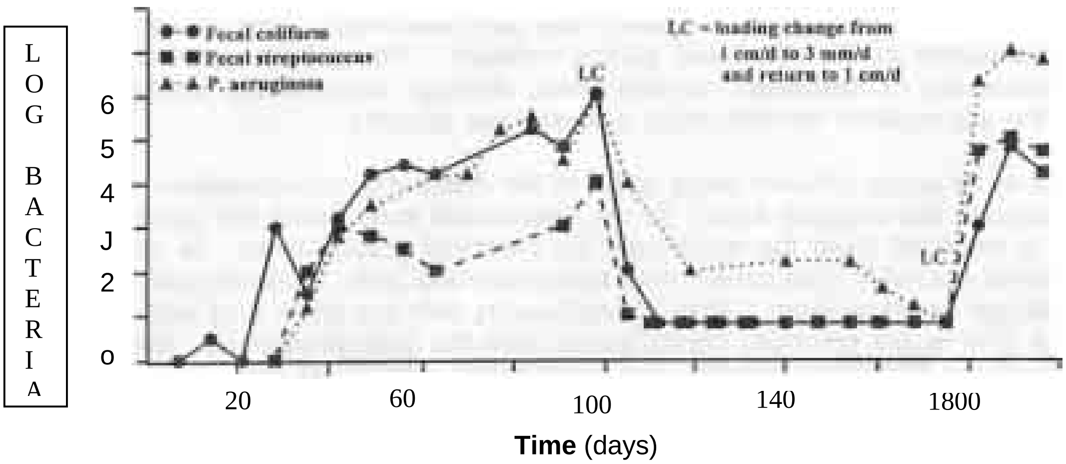

Fig. 6. Effect of loading rate on breakthrough of selected bacteria strains. (adapted from Ziebell, 1965).

This principle is partly responsible for the increase in required disposal area in the current edition of Title 5. It is also the reason that stacked pits do not provide adequate treatment. For example, a 6-foot diameter circular concrete pit (wet height of 8 feet) surrounded with 4 feet of gravel has a bottom area of about 155 square feet. A 330 gallon per day design flow results in an actual loading rate of 2.1 gal/square feet/day (3.4 inches of effluent per day). The current Title 5 only permits loading rates of 0.74 gallons per day which is one-third of what was permitted under the old code. The end result is that under the new code less effluent per unit area of soil is applied resulting in lower loading rates and presumably better purification of the wastewater. This effect is most prevalent in coarse soils. Whereas lower wastewater loading rates enhance removal and die-off of bacteria, the same may not be true for the much smaller viruses. High loading rates and saturated soil conditions in the zone beneath the leaching facility should be avoided because of potential problems with pathogens.

There have been published reports expressing concern about the release of pathogenic viruses by septic systems. These same concerns may under certain conditions, also apply to standard municipal wastewater treatment plants. The advance of alternative technologies may bring about better treatment potential of these microorganisms. Until that time the low-cost gravity septic system discharging through the soil into the groundwater will remain the preferred choice of many designers. Prediction of the fate of viruses in the unsaturated soil environment is difficult because of the difference in surface properties as well as electric charge between the various microbial groups. Some municipalities have increased setback requirements because of pathogen concerns. This practice, however, may not be entirely correct because some pathogens will move under saturated flow conditions, while the majority of microorganisms are trapped and destroyed within the unsaturated soil zone underlying the leaching facility.

MISCELLANEOUS ISSUES

Percolation Test

The percolation test has been used to assess the ability of the soil to accept wastewater. For many years it was used in the design of on-site sewage disposal facilities, but increasingly designers are realizing the shortcomings of the percolation test in predicting what happens under actual field conditions. One of the drawbacks of the percolation test is the fact that the percolation rate is dependent on the diameter of the percolation hole.

The infiltrative surface area to liquid volume ratio increases with smaller diameters. Small holes therefore result in lower percolation rates (less time per inch of water drop). For example, a 6-inch diameter hole has a percolation rate about double that of a 12-inch hole in the same soil material. Title 5 addresses this issue by requiring that percolation test holes be 12 inches in diameter.

The percolation test is used in the new Title 5 to assess whether or not there is sufficient depth of pervious material available at a proposed building site. It is the job of the site evaluator to identify the soil layers that potentially may restrict the movement of the septic tank effluent through the soil. The most restrictive layer always should be tested. A problem may arise when this restrictive layer is less than 12 inches thick. The more pervious layer may contribute significantly to the final results when the percolation test is performed in such soils. This problem is illustrated in Fig. 7, where a sandy layer intersects the percolation hole. The observed percolation rate depends, to a large extent, on the sandy seam if this layer is continuous. In this case, the measured flow is indicative of lateral flow rather than the vertical flow that occurs under an actual leaching facility. Soil evaluators should be aware of this situation when assessing layered soils. Perhaps some different permeability test or preferably, a shallower hole may be employed to properly evaluate these conditions. Under no circumstances should a percolation hole less than 12 inches in diameter be used.

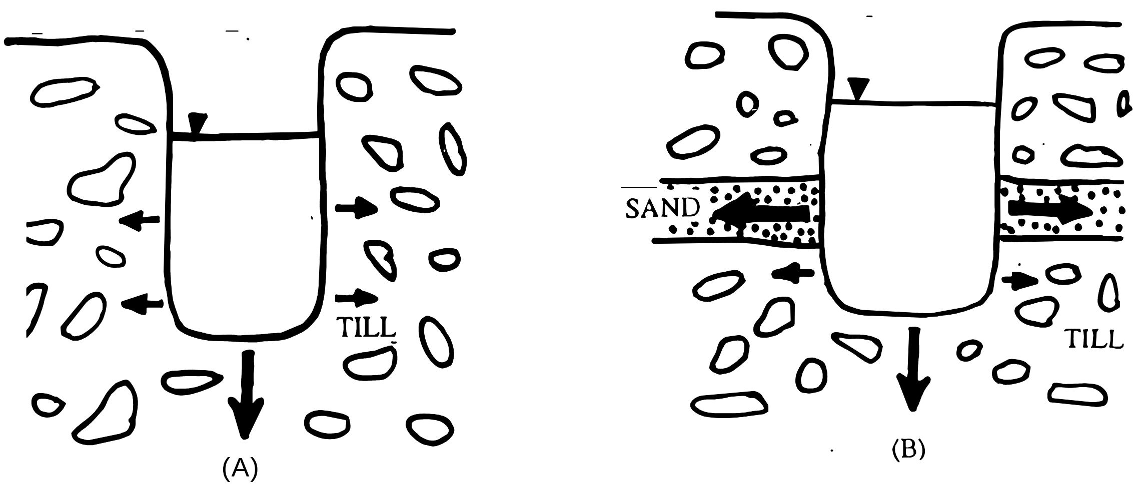

Fig. 7. Cross-section through a percolation test hole in a homogeneous (A) and a layered soil (B). Note that the sandy layer to a large extent determines the percolation rate in (B).

Groundwater Mounding

Groundwater mounding refers to the elevation of the water table directly below the leaching facility where the purified effluent reaches the groundwater. If the lateral permeability of the substratum is somewhat limited, the percolating effluent tends to accumulate under the leaching facility as illustrated in Fig. 8. Considering that only soils with percolation rates faster than 30 minutes per inch can be used for on-site sewage disposal, groundwater mounding in residential systems generally is negligible. Under large systems, however, with design flows exceeding 2,000 gallons per day, the possibility of groundwater mounding should be assessed by a qualified individual. Soils that have percolation rates close to or exceeding 30 minutes per inch (silt loam and silty clay loam textures) are especially prone to mounding. The potential rise can be easily calculated using Darcy's Law assuming representative lateral hydraulic conductivity values. Once a value for the potential groundwater mound is calculated, this value should be used as a correction factor in assessing the depth of pervious soil above the water table.

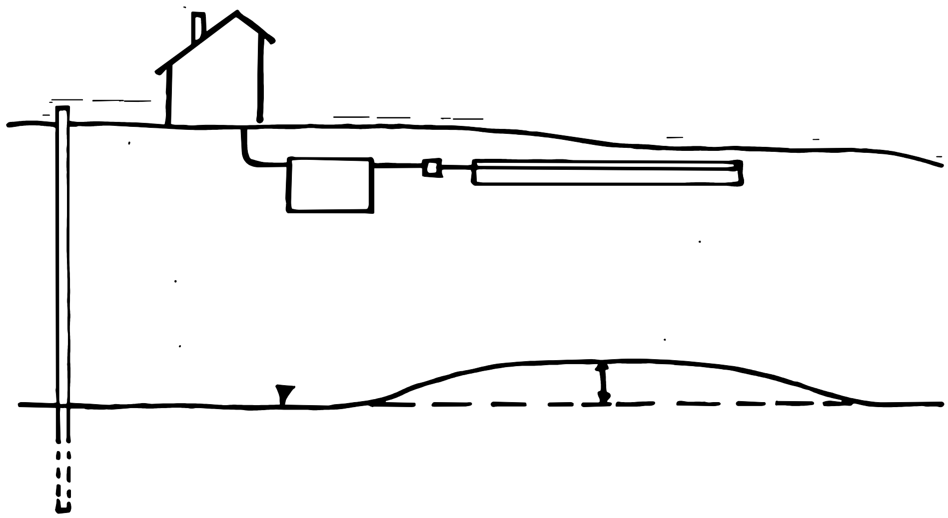

Fig. 8. Groundwater mounding under a leaching facility. Drawing is not to scale.

Cesspools

Cesspools generally are deep systems, lacking a septic tank. The system is constructed from bricks, concrete blocks or even rocks placed in a circular, generally inverse-cone shape fashion such that the ends of the bricks are not touching. Household wastewater is piped directly into the honeycomb structure, and the effluent is allowed to flow freely through the cavities between the bricks. The large volume of the cesspool provides ample storage space, however, this is often negated by the settling of solids onto the bottom. Over the years the cesspool may slowly fill up, resulting in hydraulic failure when effluent surfaces or the sewage backs-up into the house. Whereas this type of failure is fairly easy to recognize, these systems are also prone to environmental failure. Because of their depth, cesspools generally require deep soils. Many Massachusetts soils are relatively shallow or have high seasonal water tables causing the lower portion of the system to remain submerged in groundwater for periods of time. Saturated soil conditions do not favor efficient effluent treatment. Harmful compounds and organisms, nutrients, and bacteria and viruses may then be released to the environment.

These systems often are used on small lots because they do not occupy a very large area. The cross-sectional bottom area, through which all the effluent eventually must pass, is relatively small. Cesspools therefore have actual effluent loading rates over 3 inches of effluent per square foot per day. This high loading rate does not promote a high degree of treatment, particularly in regards to the removal of pathogenic microorganisms. New cesspools have not been approved for installation since 1977, when the previous Title V was promulgated. In certain regions, a large number of cesspools are still operating. Particularly when partly situated in the groundwater these systems should be considered failing and be replaced.

Pressure Dosed Systems
In situations where one may expect that the clogging layer will not develop to its fullest extent, such as in coarse sandy soils and in fill when the soil potentially allows for rapid saturated flow, or in very large commercial systems, it is prudent to install a pressure dosing system. Upon leaving the septic tank the effluent is stored in a pumping chamber, from which it is pumped either at preset intervals or by preset volume into a distribution system with small (1'/2 inch) pipe. The holes in the distribution pipe are smaller (about 1/4 inch) than those in standard 4-inch PVC pipe and are spaced somewhat irregularly based on the pressure loss in the pipes. When properly designed, these systems ensure even effluent distribution throughout the leaching facility, which in turn facilitates low loading rates (actual amount of effluent applied per square foot), unsaturated flow, and improved treatment efficiency. The pumping chamber, pump and additional hookup results in somewhat higher costs than conventional systems. This cost difference should diminish once designers and installers become familiar with this technology.

At the present, the cost of these systems is unreasonably high as compared to surrounding states.
In very large systems pressure dosing is often combined with periodic resting of the system. This is attained by splitting the system, often in half or in quarters in very large systems, and using one-half of the system at any one time. After a period of time, generally one or two months depending on the system, the flow is switched to the rested leaching facility. This method has the advantage of periodic resting and also of spreading the effluent over a larger area.

Alternative Technologies
Title 5 allows for the use of alternative systems when certain conditions apply. Particularly in nitrogen sensitive areas the removal of nitrogen from the effluent is required. Alternative technologies are also suited to repair situations, where the installation of conventional systems is precluded because of limiting site conditions. When properly designed, installed and maintained, alternative technologies can provide advanced treatment thereby reducing strict siting requirements. There are several advanced treatment systems that are currently approved for use in Massachusetts, while others are still in the pre-approval stage. Claims are made about the usefulness of these systems for a variety of purposes, and the user as well as the Approving Authority should check with DEP personnel about the applicability of these systems for a given site and environmental condition.